United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

TEMPERATURE-HUMIDITY CONTROLLED CABINETS FOR THE STUDY OF INSECTS 1/ 2/

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The present apparatus was designed for use in studies of the beet leafhopper (*Eutettix tenellus* (Bak.)) in relation to some of the more important physical factors of the environment as an aid in interpreting problems of distribution, development, activities, and abundance in terms of the more significant variables involved. The cabinets have proved satisfactory for such studies during extensive use over a period of several years. The description provided is quite general, since many of the detailed features are arbitrary and may be modified or improved in many ways.

General Description

The equipment may be generally described as consisting of three major parts, viz., the five air chambers or controlled cabinets, the brine tank and brine circuit through cooling coils in the different compartments, and the ammonia compressor and expansion coils for controlling the temperature of the brine (fig. 1).

The cabinets were well insulated to obtain a wide range of temperatures and greater efficiency in the cost of operation. Different constant-temperature and humidity conditions were obtained by automatically controlled heaters and humidifiers and the cooling and dehumidifying action of the brine coils.

1/ The equipment described was constructed in 1932 at the Twin Falls, Idaho, laboratory of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. The writers are indebted to R. A. Fulton for suggestions on the design of the equipment, to J. R. Douglass for suggesting certain improvements, and to E. H. Bean for various suggestions and assistance in construction of the cabinets and installation of apparatus.

2/ A brief description of the controlled cabinets was given Prof. Alvah Peterson in 1933 for inclusion in his manual of entomological equipment and methods (Plate 124) (A Manual of Entomological Equipment and Methods, Part I, 1934. Michigan: Edwards Bros. Inc.).

It was possible to produce a wide range of conditions and to maintain satisfactory control over long periods. The cabinets were operated at constant temperatures ranging from 5° to 120° F. Differences in relative humidity between 10 and approximately 100 percent were obtained within ordinary temperature extremes for insect development and oviposition activity. Variation in constant temperatures was about two-tenths of a Fahrenheit degree above or below the temperature desired, and relative humidity was regulated within a range of about 1 to 2 percent. The degree of temperature-humidity control is illustrated by hygrothermograph records in figure 2.

Structure of the Cabinets

The cabinets were constructed of pressed-cork panels (2 by 12 by 36 inches), suitably strengthened by a wooden framework consisting of 2 by 4's at the upper and lower edges, with uprights placed at the corners and in the center of the back wall of each chamber for supporting the brine coils. Single pieces of cork were cemented and nailed into the structure. The floor, ceiling, and outer walls were insulated with 4 inches of cork (two layers of panels), and partition talls between compartments were 2 inches thick. The floor was supported by a wooden panel laid over 2 by 4 inch cross pieces occurring below the partition walls and the center of each compartment. Windows were placed in the ceiling of each chamber and were supported by running the compressed-air line (1/4-inch steel pipe) and wiring conduit longitudinally through the ceiling wall on each side of the window frame. (Wooden cross pieces are also recommended for supporting the weight of the window frames).

The cork material was also used to build out the back and side walls of the cabinet for a distance of about 6 inches in each corner to form a niche in the center for the brine coil (fig. 1). Pressed-board panels about 6 inches wide were nailed over the cork, and a removable panel of the same material was mounted over the center section to separate the brine coil from the remainder of the chamber (figs. 3 and 4).

The outside of the cabinet measured 13 feet and 10 inches in length, 4 feet and 6 inches in width, and 3 feet and 4 inches in height. Inside dimensions of the different compartments were 38 inches in depth from front to back, 30 inches in width, and 32 inches in height.

The interior of the cabinets was made tight and waterproof by covering the surface of the cork with a thick layer of emulsified asphalt. Floors of the cabinets were covered with a hard pressed-asbestos board placed over the cork. The interiors of the compartments were finished with aluminum paint to give a better surface for reflecting light. The front of the cabinet, including the outer

doors, was constructed by a cabinet maker as a unit or panel that was attached by means of large lag screws entering the 2 by 4's of the wooden framework (fig. 3). Large doors, used to give free access to the cabinets, were insulated with 4 inches of pressed cork and were properly fitted with rubber gaskets to prevent air leakage. Inner doors were made of three-ply pine veneer, coated with asphalt paint, and provided with an observation window and smaller doors to permit examinations or adjustments of the control equipment without disturbing the experimental conditions (fig. 1). (Since some expansion of the inner doors occurred under moist conditions, construction of pressed-board material instead of veneer would evidently prove more satisfactory.) Electrical outlets were placed in each compartment for the convenient attachment of control apparatus. The front surface, including the outer doors, was constructed of finished birch, and the remainder of the exterior was covered with pressed board having a smooth, durable surface and good insulating properties. The cabinet was finished by staining and varnishing the exterior.

The Brine Tank and Cooling Circuits

The brine tank (fig. 1) was constructed of 10-gauge steel and was insulated with a 4-inch layer of pressed cork and an outer protective casing of wood. Inside dimensions of the tank were 2 by 6 by 3 feet, giving a capacity of about 200 gallons. The refrigeration coil consisted of about 150 linear feet of 1-inch ammonia pipe that was arranged to leave the center of the tank free for accommodating containers used in making ice (fig. 1). The inside of the tank and the outside of the ammonia expansion coil were covered with a protective coating of tar to prevent oxidation and corrosion. The tar was melted and applied with a brush while the metal surfaces were heated. (Since some leakage has occurred after several years of use, a wooden brine tank is evidently to be recommended.)

The brine circuit consisted of 1-inch pipe connected through ordinary wall-type heating radiators in the controlled chambers by appropriate fittings. As is shown in figure 3, the pipe was placed along the back of the cabinet and was connected through the coils by a by-pass arrangement so that the flow of brine to different compartments could be independently regulated or shut off by means of hand-operated valves. The brine pipe was covered with pressed-cork pipe insulation, 2 inches in thickness (fig. 3). Brine was circulated through the pipe and coils by a centrifugal pump operated by a 3/8-horsepower motor. The temperature of the brine was automatically regulated within a range of about 2° by the starting and stopping of the ammonia compressor under the cntrol of an immersion thermostat placed in the brine tank (fig. 1).

Temperature Control

Temperature control was obtained through the counter action of the cooling coils and resistance heaters controlled by thermostats. The heaters were adapted from a common type of heat convector and consisted of resistance wire mounted over porcelain insulators on a metal frame. The heaters were usually employed at about 200 watts capacity, but the load could be increased if necessary by changing the line wires to different terminals. Heating elements were mounted directly in front of the circulating fans (figs. 3 and 4) to give a minimum of lag before and after operating. These were controlled by mercury-glass thermoregulators of the sealed type containing dry hydrogen to dampen the spark and prevent failure through oxidation at the contact. The thermostats were used with small relays designed to reduce voltage and current on the instrument contact.

Since the temperature of the brine could not be independently regulated for different temperatures in the various compartments, the amount of cooling and heating was controlled to a considerable extent by limiting the passage of air over the brine coils. Unnecessary cooling and heating at the higher temperatures was reduced in this way by closing the air vents or adjustable ventilators in the panel in front of the brine coil (figs. 3 and 4).

Humidity Control

Atmospheric humidity was controlled through the dehumidifying action of the brine coils and automatic operation of spray-jet humidifiers. The humidifiers consisted of a common type of atomizer mounted over a reservoir made of sheet copper. A small baffle was placed in front of the jet to increase the rate of humidification by breaking the spray in finer particles. The upper half of a glass bottle was inverted over the reservoir to trap the larger spray droplets (fig. 3). The humidifiers were later modified by soldering the air line through the bottom of the reservoir and connecting the atomizer in a vertical position. A band of copper wire screen around the top of the reservoir served to trap the larger drops of water (fig. 4). The atomizers were operated with compressed air at 15 to 20 pounds of pressure and were controlled by humidostats through the action of solenoid valves placed in the air line (fig. 3). Humidostats of a common commercial type, employing human hair as the sensitive element, were used with small three-wire relays to prevent jumping of the valve through arcing on the instrument contacts during completion and breaking of the pilot circuit. The rate of dehumidification was controlled by regulating the temperature of the brine and the passage of air over the brine coils. Water condensing on the brine coils was trapped and returned to the reservoirs of the humidifiers (fig. 3). When brine temperatures were below freezing there was a gradual accumulation of ice on the coils and it was necessary to add water to the

reservoirs at intervals to maintain the supply. When brine temperatures were above 32° F. it was occasionally necessary to siphon off an excess accumulation of water resulting from transpiration of the plants.

Since the different chambers were operated with brine at the same temperature to obtain different temperature-humidity conditions, the rate of dehumidification at higher humidities (especially in combination with higher temperatures) was much more rapid than necessary and required a corresponding excess amount of compressed air to operate the humidifiers in counter action. For better operation as well as greater efficiency in current consumption and cost of operation, ventilators or air valves were used to regulate the amount of air passing over the brine coil (figs. 3 and 4). By this method the rate of dehumidification was regulated satisfactorily to obtain widely different temperature-humidity conditions in different chambers with brine at the same temperature.

Cost of Materials and Apparatus

Cost of the equipment, exclusive of the air and ammonia compressors and considerable part-time labor of laboratory workers, is estimated at about $1,000. The following list of materials and apparatus is appended as a guide in estimating the approximate cost of similar cabinets or particular features of the control equipment.

Cabinet structure

Pressed cork	$70.00
Cement for joining cork panels	25.00
Lumber and nails	6.50
Screws and bolts	2.00
Cabinet front with outer doors (materials and labor)	84.00
Hinges and fasteners for outer doors	15.50
Inner doors (materials and labor)	21.50
Emulsified asphalt for interior of cabinets	25.00
Glass for windows	4.00
Asbestos board for floors	19.00
Pressed board for paneling brine coil chambers	10.00
Pressed board for exterior of cabinet	18.00
Lights and electrical wiring	50.00
Metal base or stand for cabinet	26.00

Brine tank and brine circuit

Brine tank and expansion coil (materials and labor)	$100.00
Pipe and plumbing connections (materials and labor)	70.00
Centrifugal pump and motor for circulating brine	70.00
Five gate valves	8.75
Automatic ammonia expansion valve	20.00
Five wall radiators (in cabinets)	21.00

Installations

Five thermostats	$70.00
Five relays (two-wire)	50.00
Five electric heaters	8.00
Five 10-inch electric fans	23.00
Ten ventilators	10.00
Five humidostats	90.00
Five relays (three-wire)	55.00
Five solenoid valves (in compressed-air line)	80.00
Total	$1,052.25

Summary

Cabinets and apparatus for the precise control of temperature and atmospheric moisture over a wide range of conditions are described. Constant temperatures were obtained through the counter action of cooling coils, and of resistance heaters controlled by thermostats. Constant humidity conditions were obtained through the dehumidifying action of low-temperature coils and humidifiers controlled by humidostats. Cost of the equipment is roughly estimated at about $1,000, exclusive of the air compressor and the refrigeration machine.

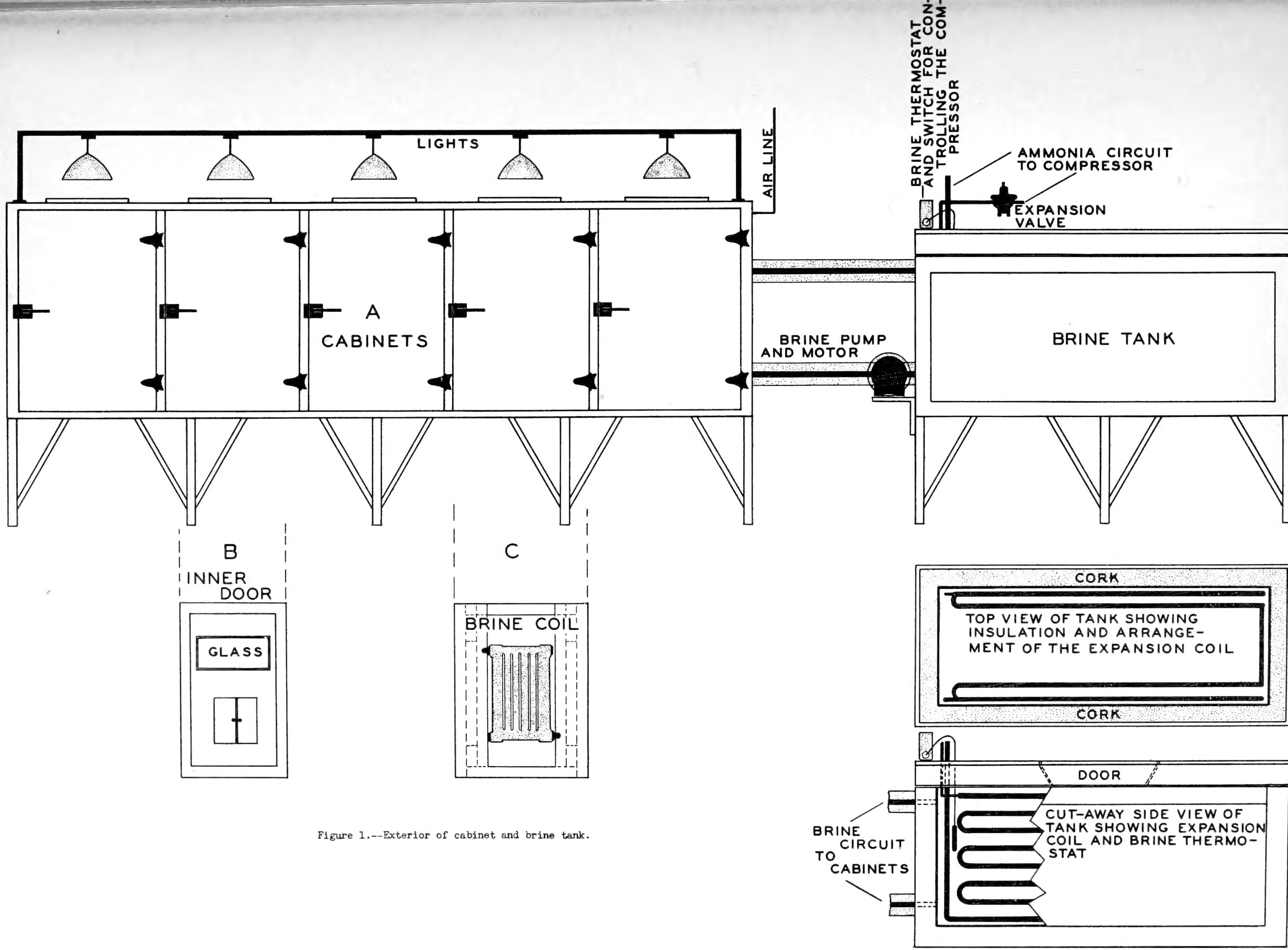

Figure 1.--Exterior of cabinet and brine tank.

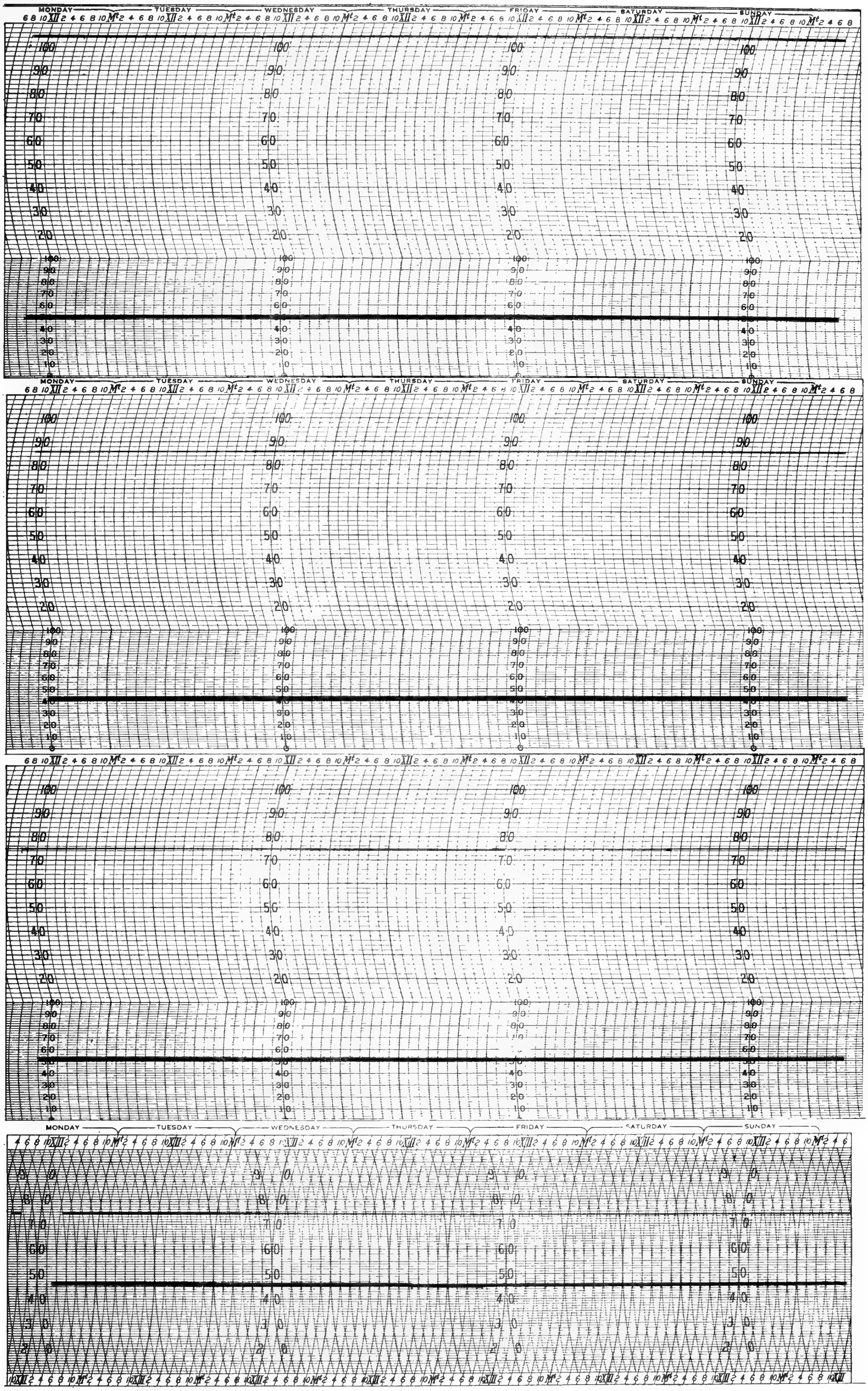

Figure 2.--Hygrothermograph records from controlled cabinets.

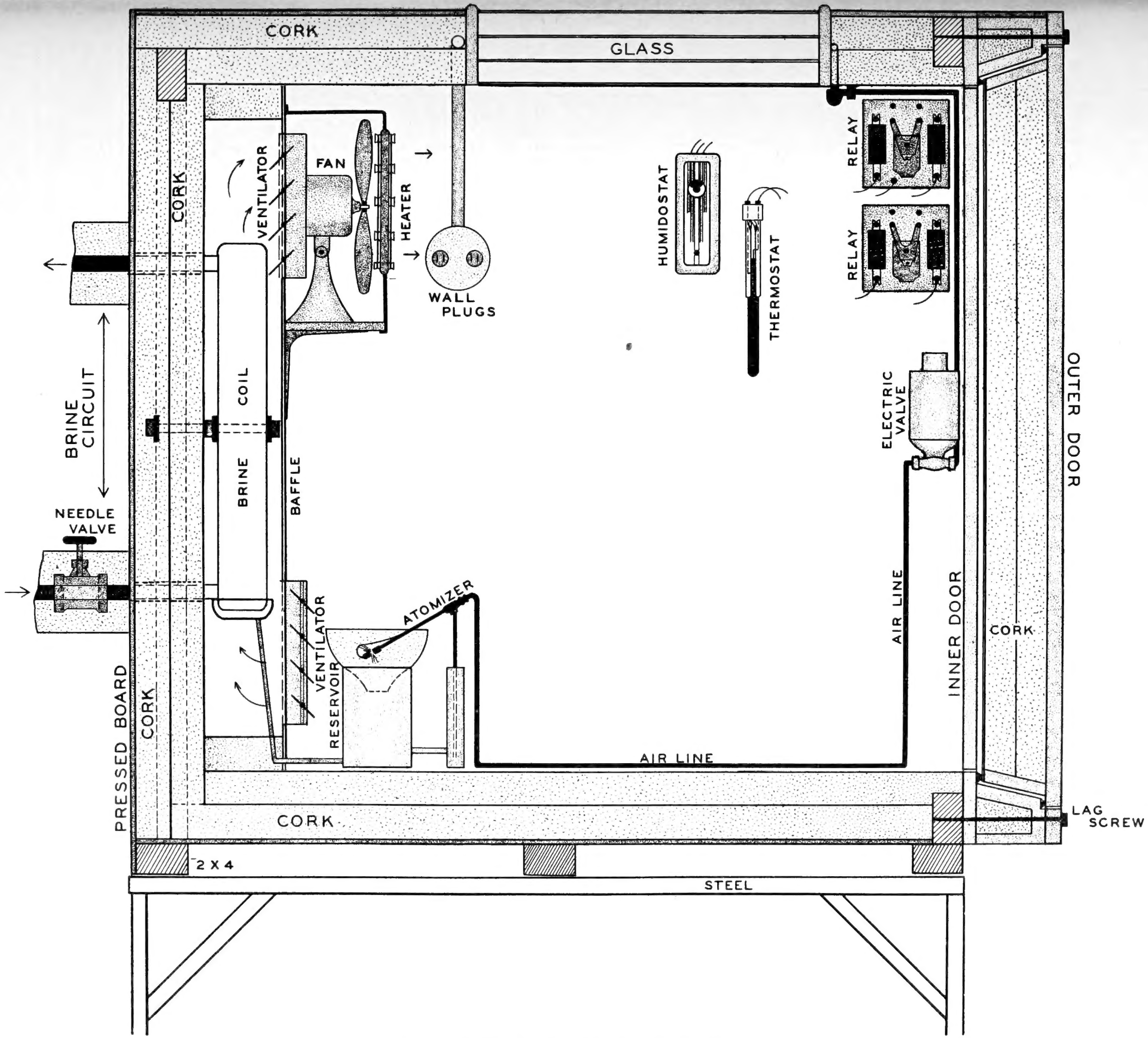

Figure 3.--Interior of cabinet showing detail and arrangement of control equipment.

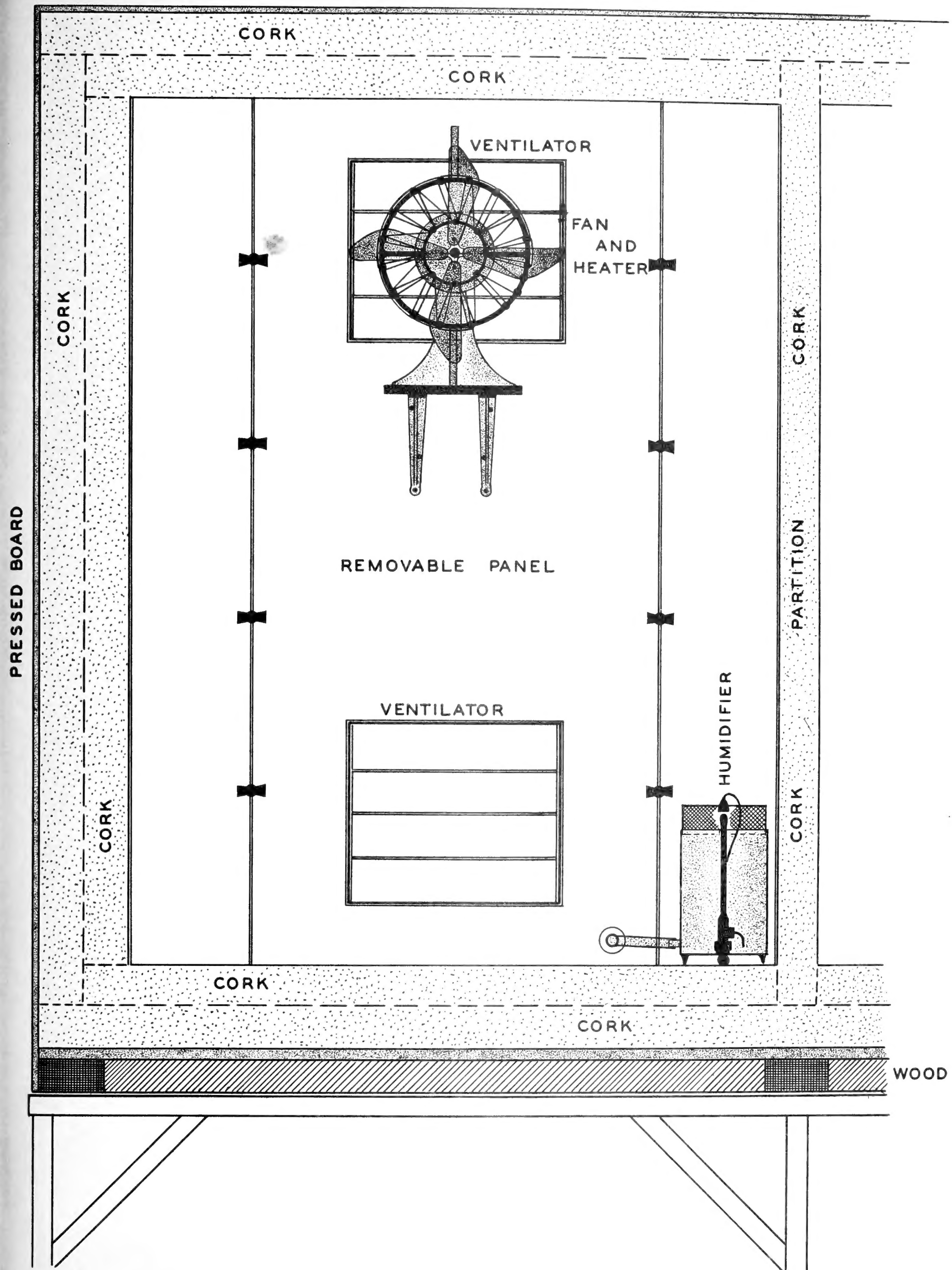

Figure 4.--Front view of cabinet interior showing panel and ventilators in front of the brine coil.